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LOP-NOR—A CHINESE LAKE.*

BY

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PART II.—THE HISTORIC LAKE (LOP-NOR).

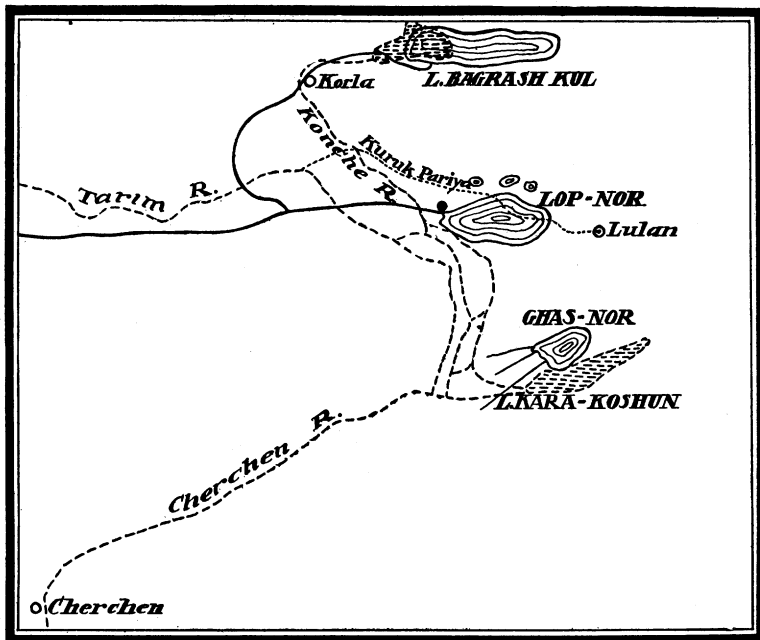
After the recovery of the camels, I completed my work in the unexplored portion of the Lop desert by travelling southwest to the ruins of Lulan, which I have discussed elsewhere, and then west to the Tarim River. Having thus been the first explorer to complete the circuit of Lop-Nor, I was in a position to estimate fairly the merits of the controversy which has arisen as to the identity of the reedy modern lake of Kara-Koshun with the Lop-Nor of the ancient Chinese. Przhevalski, the Russian discoverer of Kara-Koshun, believed that it was the shrunken representative of an expanded Lop-Nor of ancient times, but he does not carry the matter to any definite conclusion. Hedin, to whom we owe most of our knowledge of the region, believes that any great permanent change in the size of the lake during historic times is impossible, and that, though Kara-Koshun and Lop-Nor were both fed by the Tarim River, they were never parts of a single lake. My own view includes certain elements of both the preceding views. Kara-Koshun seems to be the small modern remnant of a large ancient Lop-Nor; but in the period from about the third to the eighth centuries of our era Lop-Nor seems to have contracted to small size and to have occupied the position assigned to it on old Chinese maps, about a degree north of Kara-Koshun.

In travelling around Lop-Nor, I discovered that the old lake-bed is surrounded by terraces and by ancient aqueous deposits. The latter consist of greenish, lacustrine layers of fine clay of uniform texture, alternating with reddish, non-lacustrine layers of coarser material full of lenticular beds of sand and fine gravel, which must have been deposited subaërially at a time when the lake had contracted in size. These alternating deposits, like similar ones at Turfan, one or two hundred miles to the north, and at Seyistan (Sistan), far away in Persia, indicate that previous to the series of epochs of *decreasingly* severe climatic fluctuations known as the Glacial period, there was a series of epochs of *increasingly* severe

* Continued from February BULLETIN, p. 77.

fluctuations of which the record has not yet been investigated. This indicates that in the most recent geological times climate has been much more variable than is generally supposed.

The record of the *decreasingly* severe series of changes is preserved in six lacustrine strands, lying at heights of approximately 600, 300, 115, 35, and 12 feet above the present level of Kara-Koshun. The figures are approximate: the lowest strand is at least two or three miles from the lake and often ten or twenty, and I had no means of levelling. The two oldest strands lie far from the lake and are much covered with talus, but can be clearly distinguished



MODERN EDITION OF AN ANCIENT CHINESE MAP, AFTER WAGNER AND HIMLY'S WU-CHANG-FU MAP.
THE DOTTED LINES SHOW MODERN LOCATIONS OF LAKES AND RIVERS.

where they lie at the foot of huge bluffs cut in the front of fans, as at Jilluck, between Vash Sheri and Charklik. The youngest strand is very faint and very recent. In number, relative size, and relative age the strands agree with the terraces which occur in most of the valleys of Central Asia, and with the old moraines high up in the mountains. The close agreement of these three sets of phenomena makes it highly probable that they are all due to a single series of climatic changes. If, then, as we shall see some reason for believing, the lowest strand of Lop-Nor was formed during historic times, we

must conclude that the last faint pulsations of the Glacial period have as yet scarcely died away.

Modern Lop-Nor, or Kara-Koshun, like all lakes of its class occupying part of the sediment-covered floor of an enclosed basin, is very shallow and lies in an extremely flat plain. Consequently it has changed its position during historic times. When Przhevalski discovered Kara-Koshun it proved to lie a degree farther south than the Lop-Nor depicted on old Chinese maps such as that which is reproduced in part in the heavy lines on the opposite page. The Chinese were able to determine latitude with a high degree of precision, but in their determination of longitude they were liable to large errors. In the map before us Lop-Nor should lie a degree farther east; the solid black dot which I have inserted at the west end of the lake ought to coincide with Lulan. Combining all the data procured by Hedin and myself with those derived from the Chinese maps, it appears that in ancient times, as shown in the sketch map of East Turkestan on page 140, the Tarim River flowed along the now dry bed of the Kuruk Dariya marked (1) on the map, and divided into two arms, one emptying into some little lakes of which I discovered the dry beds, the other into the main lake of Lop-Nor, south of Lulan. A little later only the latter channel was used. Then the river shifted into one or both of two dry channels which I discovered farther west. They are bordered by a dry poplar forest, which does not appear to have been dead so long as that beside the Lulan channel; the natural inference is that the one farther west is younger. Finally, the stream swung still farther to the right and assumed in the main its present course, although in the lowest fifty miles it has kept on changing its bed in even later times, as may be seen from the map where the successive courses are numbered. At present the river flows nearly south from Tikkenlik to the almost dry lake of Kara-Buran at the mouth of the Cherchen River and then east to Kara-Koshun. Apparently one or the other of these is the modern representative of the Ghas-Nor of the old Chinese map, although Hedin and one or two Russian authors have doubted it.

Various causes appear to have contributed to the migration of the Tarim River and its terminal lake. In regard to the latter, Hedin has proved by an exact survey that the region between Lulan and the southern shore of the Kara-Koshun lake—that is, the old bed of Lop-Nor—consists of two shallow basins. Farther east I found that the same is true, as is evident from the greater salinity and dampness of the hollows, and from the fact that, although the horizon appeared perfectly flat, a broad view opened both to north and south

when we insensibly ascended to the top of the central swell. We saw the whole of mountains whose tops alone had previously been visible. The Lop-Nor of the Chinese maps occupied the northern hollow; the modern Lop-Nor occupies the southern. Silt brought in by the river, sand deposited by the wind, carbon from reeds, and the remains of animal life must rapidly fill the shallow hollow where water stands and raise it above the level of its dry neighbour, whose bottom is subject to constant deepening by the wind. Hence the lake must change its position. Hedin assumed that the change must have a pendulum-like regularity, and that the river must follow the lake. In 1900 and 1901 he seemed to find the beginning of a swing back to the north, for one of the old river-channels, number 4 on the map, had been reoccupied by water, and a considerable area to the north of Kara-Koshun was being rapidly flooded and converted into new lakes and gulfs. Five years later, however, I found that the whole region had returned to the old condition of aridity. The level of the main river and of all its marginal lakes had fallen four or five feet, and that of the terminal lakes of Kara-Koshun had also fallen. Hedin's visit coincided with a time of exceptionally high water; mine with a more normal period.

Changes in the course of the Tarim River probably have more influence on the position of the lake than *vice versa*. Hedin attributed the migration of the river to two chief causes—namely, a supposed tendency of rivers to cut to the right in the northern hemisphere because of the earth's rotation, and the effect of the prevailing northeast gales in driving the water in erosive waves to the right bank of the river and in filling up the left side with wind-blown dust. Recent investigations of the Mississippi have thrown grave doubt on the theory of a right-handed deflection of rivers by the earth's rotation. The wind, however, is probably an effective factor. Another important cause of the peculiar changes in the course of the Tarim River may perhaps be found in the influence of the zone of vegetation. During the driest of the Inter-Glacial—or, as they may here better be called, Inter-Fluvial—epochs, the river, apparently, decreased in size so that it was not only unable to form a lake, but withered to nothing far up-stream. During the succeeding Fluvial epoch of lower temperature, or of greater precipitation, or both, the river must have regained its length. In doing this it would be easy for it to flow eastward along the zone of vegetation which everywhere lies at the lower edge of the zone of piedmont gravel and parallel to the base of the mountains; but it would be difficult to break southward through the rampart of sand which always accumu-

lates on the border of an area of vegetation. Thus the river appears to have acquired an unstable position, flowing across instead of down the main slope. Whenever it accidentally broke through the retaining wall of sand it swung to the right. Thus it is gradually setting back to a normal course in the lowest part of the basin. If to this tendency of the river to change its course we add the influence of a changing climate with a period of especial aridity culminating between the fourth and eighth centuries of our era, all the known facts in regard to Lop-Nor and the Tarim River find adequate explanation. The problem is extremely complex, however, and the theory here advanced finds its strongest proof in regions outside Lop-Nor.

The earliest-known fact as to Lop-Nor is that the ancient Chinese called it *the* "Great Salt Lake." No one would think of doing so to-day, for the greatest expanse of open water is only five or ten miles. The old Chinese also called it a "Marsh," and the "Lake of Reeds," but these names probably arose at a later date than that of the "Great Salt Lake," at a time when the expanse of water was less. As to the actual size of the lake, the old records are diverse. The history of the first Han dynasty, written about the time of Christ, gives the size of the lake as seventy-five miles each way. At this time Lulan must have consumed much water, which would naturally diminish the area of the lake. A later record of unknown date, but probably belonging to the centuries of great aridity, says fifty miles by twenty-five; and another, one hundred miles in circumference, which is still smaller. Whether these figures refer to the entire marsh or only to the area of open water is uncertain. Hedin gives the size of the modern Kara-Koshun as seventy-five miles by eighteen, including all the marshy tract, which, he says, comprises nine-tenths of the entire area. Przhevalski gives sixty or seventy miles by thirteen; but his map diminishes this. So far as any conclusion is justifiable from such meagre data, it appears that in the very earliest times Lop-Nor was larger than now, in spite of the great drain on the water of the Tarim and its tributaries for the support of the dense population of that day. Somewhat later, at an unknown but early date, the lake seems to have been of much the same size as now.

Hedin, who utterly scouts the idea of any change of climate during historic times, recognizes that during certain periods Lop-Nor has been distinctly larger than it now is, even during times of unusually high water. He explains this on the assumption that during those periods the number of marginal lakes and swamps on the Tarim River was less than now. This is not probable. When a

river has reached the mature stage of the Tarim the average quantity of water diverted to marginal lakes is nearly constant throughout any period of long duration, though it may vary from year to year. A *permanent* change in the size of the lake could not result from this cause. Moreover, a comparison of the conditions in 1900 with those in 1906 shows that, in one case at least, the river, the marginal lakes, and the terminal lake all expanded and later contracted *in unison*.

There is reason to believe that in the Middle Ages Lop-Nor was decidedly larger than now. Rev. G. W. Hunter, of the China Inland Mission, kindly translated for me part of an ancient local Chinese account of Tung Hwang (Sa-Chow) which he had picked up in that city. In this there is an itinerary of the ancient trade route, from Tung Hwang to the Lulan region and westward—a route which was the main artery of trade between China and the West up to the second or third century of our era, but is now utterly unused because of the entire absence of water. At a distance of one hundred and eighty miles (seven hundred and ten li) from Tung Hwang this “very important road,” as it is called, is said to reach the Cho-hu-tong lake, which must be Lop-Nor, as it is connected with the Ta-leng-mu (Tarim) River. This would necessitate the expansion of the lake to a point eighty miles east of Lulan and fully fifty from the present eastern end of the Kara-Koshun marsh; and the water would have to rise nearly or quite to what I have called the twelve-foot strand. The itinerary dates from medieval times; for it does not mention Lulan, which had ceased to exist, having been largely destroyed by 300 A. D. and completely by or before 800 A. D., so far as can be ascertained.

Other facts agree with the itinerary. Grenard speaks of having seen at Keriya a Chinese map dating from the eighteenth century, but probably based on earlier surveys, and showing Lop-Nor in its present position, but very much larger than now. Another suggestion as to the medieval behaviour of the lake is found in the destruction of the so-called Dragon-Town (Lung-shong), lying at some unidentified point southwest of Lop-Nor. The names “marsh” and “lake” are both used in the Chinese work where the history of the town is recorded. According to Himly’s translation, “Lop-Nor streamed over its banks and laid waste the land; the foundations of the city still exist. In the time of Chi-ta (1308-1311 A. D.) the overflowing water, which in the morning reached the west gate and in the evening the east gate, was driven by the wind into the form of a dragon.” Apparently, the level of the lake rose so as to completely overwhelm the city; but it is impossible to determine whether

the rise was permanent, or was temporary like that of 1900. The Lopliks did not come to Lop-Nor till some centuries after the destruction of the Dragon Town. It is a familiar tradition among them that in the days of their ancestors, two or three hundred years ago, the lake and the Tarim River were larger than now. As one of the most intelligent Lopliks said to me, "The water grew less, and that made the fish die. Then our fathers could not get enough to eat, and they began to die or move away."

More trustworthy evidence of the recent greater size of the lake is found in six little strands discovered by Hedin in his survey of the old lake-bed. They are marked by rows of tamarisk bushes, mostly small, accompanied by *limnæa* shells and drifted sand. On the older strands the bushes are for the most part dead, while on the younger many are living. The upper strand lies six feet above the highest recent level of Kara-Koshun, that of 1901, and seven and a half miles from it.

In the history of Karya-Koshun, the strands,
says Hedin,

serve as milestones marking successive stages on its way to destruction. The first . . . proves that the northern shore of the lake once extended 12 km. farther to the north than it does now, and implies that its area was then at least twice as great as it is now. On the whole . . . the lake has shrunk at a pretty regular rate.

This may seem inconsistent with Hedin's other statements; but, as already remarked, he attributes the result to an assumed—though, as later observations show, unproved—increase in the number of marginal lakes along the Tarim. On the south side of Kara-Koshun I saw less distinct traces of what seem to be the same strands. The condition of the vegetation shows that they cannot be more than a few hundred years old, and the Loplik tradition and medieval Chinese map are thus confirmed.

Elsewhere, Hedin gives what seems to be evidence that the lake stood still higher not many centuries ago:

This was a stake of tamarisk wood 35 cm. (10 inches) long, half buried in the ground, and undoubt edly placed there at a time when the locality was under water. The lower end of the stake was sharply pointed and burnt. Three of my attendants, who were Lopliks, thought that it had been used to moor canoes to, when their owners had been out on an exploring expedition, and had been unable to reach dry land before nightfall. At the present day the Lopliks in similar circumstances are accustomed to fasten two or more canoes together in some shallow place where, in case of a storm arising, they will not be in too great danger, and so pass the night in them. But it is equally possible that a shore may have run through that spot, and that the stake was situated at its edge. At all events the condition of the ground showed distinctly that it was moist when the stake was put in; for were such a post to be driven forcibly into the hard schor (salt deposit of the old lake-bed), the latter would crack and split. But the post was as fast as if it had been cast in the schor, and it required two or three smart side-blows to loosen it. This piece of wood furnished another proof that this part of the desert was once a lake-bottom, and that the lake was navigated by boats. It would be erroneous to suppose that it was a tent-stake, because the Lopliks, when away from home with their canoes, sleep under the bare sky. . . . As to the question what lake this was, and how far it was connected with the northern or the southern depression—these are matters to which I shall return again later on (a promise for the fulfillment of

which the reader searches in vain). I will here only add that the locality where we found the stake is fully 27 km. (17 miles) from the northern shore of the Kara-koschun (and seven feet above it), and that the ground slopes southwards the whole way from the former to the latter.

Another convincing piece of evidence as to the size of Lop-Nor in ancient times is illustrated in the sketch-map on page 140. On hearing that the road from Charklik to Tung Hwang crossed part of the salt-bed of the old lake, it naturally occurred to me that if the lake ever covered this region during historic times there ought to be an old road skirting the abandoned shore. Accordingly, at Chindelik, I hunted for it, and found two—one keeping everywhere at the base of the bluffs but above the twelve-foot strand, the other keeping always above the bluffs and from a quarter of a mile to a mile from them on the plain of gravel and sand at their top. A distinct track can be traced for miles, while elsewhere the road is marked by cairns of stones. For two days I zig-zagged between the two old roads, and saw them at various points, always bearing the same relation to one another and to the beaches and bluffs. The present road runs almost direct from Chindelik, where there are fairly good springs, to Sachgan Sai, the next source of water, where, however, the springs are very saline: the distance is about twenty-four miles, a long day's journey for loaded oxen, donkeys, and camels, even though the track is level and easy. *Via* the road above the twelve-foot strand the distance between the same points is about thirty-two miles—too much for one day's journey, although the track is almost ideal in texture, and perfectly level. And *via* the road above the bluffs not only is the distance still greater, about thirty-three miles, but the track runs through heavy sand in places and goes up and down more or less in crossing valleys. Along all three roads the country is absolute desert, with neither water, wood, nor forage from Chindelik to Sachgan Sai. It is scarcely probable that the old roads, involving a two-days' waterless journey, would ever have been followed if the shorter modern route, involving only one day's journey, had been practicable.

When I questioned Tokhta Akhun, my accurate and much-travelled Loplik guide, about the old roads, his reply was:

Yes, I know about the road at the foot of the bluffs. When I was a boy there was a little old man, a hundred years old, I think, and all bent up with age. He said that he had heard that when the lake was bigger than now people used to bring fish in canoes to Lachin, where canoes cannot come now. They loaded the fish on donkeys and carried them to Tung Hwang to sell. Here at Chindelik the road made a great bend to the south, which it does not make now. A few years ago (during the recent period of high water, it will be remembered), when I came this way, there was a place halfway from Chindelik to Sachgan where there was bad mud for two or three hundred yards, difficult for donkeys.

"How about the other road, the one on top of the bluffs?" I asked.

"I never heard of it," was the answer, "but I know that one summer a half-witted man of Abdal tried to go across the gravel to Tung Hwang and died of thirst. A Chinese Amban and his servant,

with a camel, came the same way from Tung Hwang one fall. The Amban reached Charklik, but the servant died of thirst on reaching Dunglik. The Chinese know all old things. Perhaps the Amban had read of this road. And I remember that my grandfather said that when he was a boy a man named Osman Bai and his servants tried the same way in summer, but got lost. They scattered everywhere in search of water. One reached Lachin and another Kurgan Sai, but Osman and two or three others died.

Apparently, the present road has only been in use one or two hundred years. Previous to that the lake was so high that the salt plain which the road now traverses was muddy, or perhaps under water. So everyone followed the circuitous dry route along the twelve-foot strand. Still earlier, however, this, too, was impracticable, apparently because the water actually reached the strand, and the road necessarily followed the still longer route over the gravel and sand above the bluffs. We have no means of dating the road exactly, but it was used in medieval times after the abandonment of the Lulan route.

To sum up the history of Lop-Nor during the last two thousand years: We have first a comparatively large lake, said to measure seventy-five miles each way, in spite of the fact that the populous towns of Lulan and of more remote regions diverted much more water than now. Next, during the early centuries of the Christian era, there is a decrease in the recorded size of the lake, even though the towns of Lulan were being abandoned and their water was being set free to reinforce the lake. Then, in the Middle Ages, there was an expansion of the lake, which cannot have been due to diminished use of the rivers for irrigation, for the population of the Lop basin at that time was greater than now, though not equal to that of the flourishing Buddhist times, a thousand or more years earlier. Finally, during the last few hundred years there has been a decrease both in the size of the lake and in the population about it. If Lop-Nor alone is considered, this sequence of events is not proved by compulsory evidence in all particulars; but it fits the facts better than any other theory as yet suggested. And, more than this, it agrees with all the data which I gathered from the whole of the fifteen hundred miles of longitude and four hundred of latitude of the Lop basin, and from Kashmir. All the facts are explicable on the theory of a secular change of climate from moister to drier conditions, with a rapid intensification in the early part of the Christian era and a slight reversal in the Middle Ages.